Growth, Catch Rates and Notes on the Biology of the Gippsland Spiny Freshwater Crayfish, *Euastacus kershawi* (Decapoda: Parastacidae), in West Gippsland, Victoria

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Over ten years (1987–1996 inclusive), 11 sites in the Bunyip and Latrobe River systems were monitored annually for the Gippsland Spiny Freshwater Crayfish, *Euastacus kershawi*. Another two sites in these catchments were sampled intermittently. During this period, 1063 crayfish were collected, with 102 individuals recaptured at least once. Growth rates calculated from recaptured crays vary widely, with a mean annual Occipital Carapace Length (OCL) increment of 6.7 mm/year. Regression analyses indicate a decreasing annual increment with increasing OCL for females, but a relatively uniform annual OCL increment for males. Males show a significant increase in annual weight increment against mean weight, whereas females exhibit only a slight increase in annual increment with increasing mean weight.

Recapture data and associated observations also suggest small resident ranges (<160 m), territorial defence behaviour and dimorphism in abdominal width; mature females have broader abdomens than adult males. Females carry between 200 and over 1000 eggs or juveniles. Individuals often emerge on to banks and burrowing activity was observed from October to mid-December and again in mid-February.

For the first four years of the survey the Latrobe River system was closed to the recreational taking of freshwater crayfish, permitting a comparison with catch rates in subsequent years; however, lack of change in harvests or size structure of populations sampled suggest that the closure did not have a significant effect on the *E. kershawi* fishery.

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KEYWORDS: *Euastacus kershawi*, Gippsland Spiny Freshwater Crayfish, growth rates, catch rates, annual OCL increment, annual weight increment, fishery closure.

INTRODUCTION

The Gippsland Spiny Freshwater Crayfish, *Euastacus kershawi* (first described by Smith 1912), is one of ten species of spiny crayfish in Victoria and is indigenous to most rivers and creeks in Gippsland. Its range extends from about the Bunyip River to almost the New South Wales border in southerly flowing streams (Clark 1936; Morgan 1986). Although the genus *Euastacus* is well represented in eastern Australia, little information has been published on the ecology of these species. Studies by Clark (1937), Morgan (1986, 1988, 1989) and Riek (1951, 1969) included some ecological and biological observations, but data on growth and catch rates or population structure are only available for two species. Honan and Mitchell (1995a, b, c) investigated another large Victorian species, *E. bispinosus*, while the research reported by Turvey and Merrick (1997a,b,c,d,e) focused on *E. spinifer* from New South Wales.

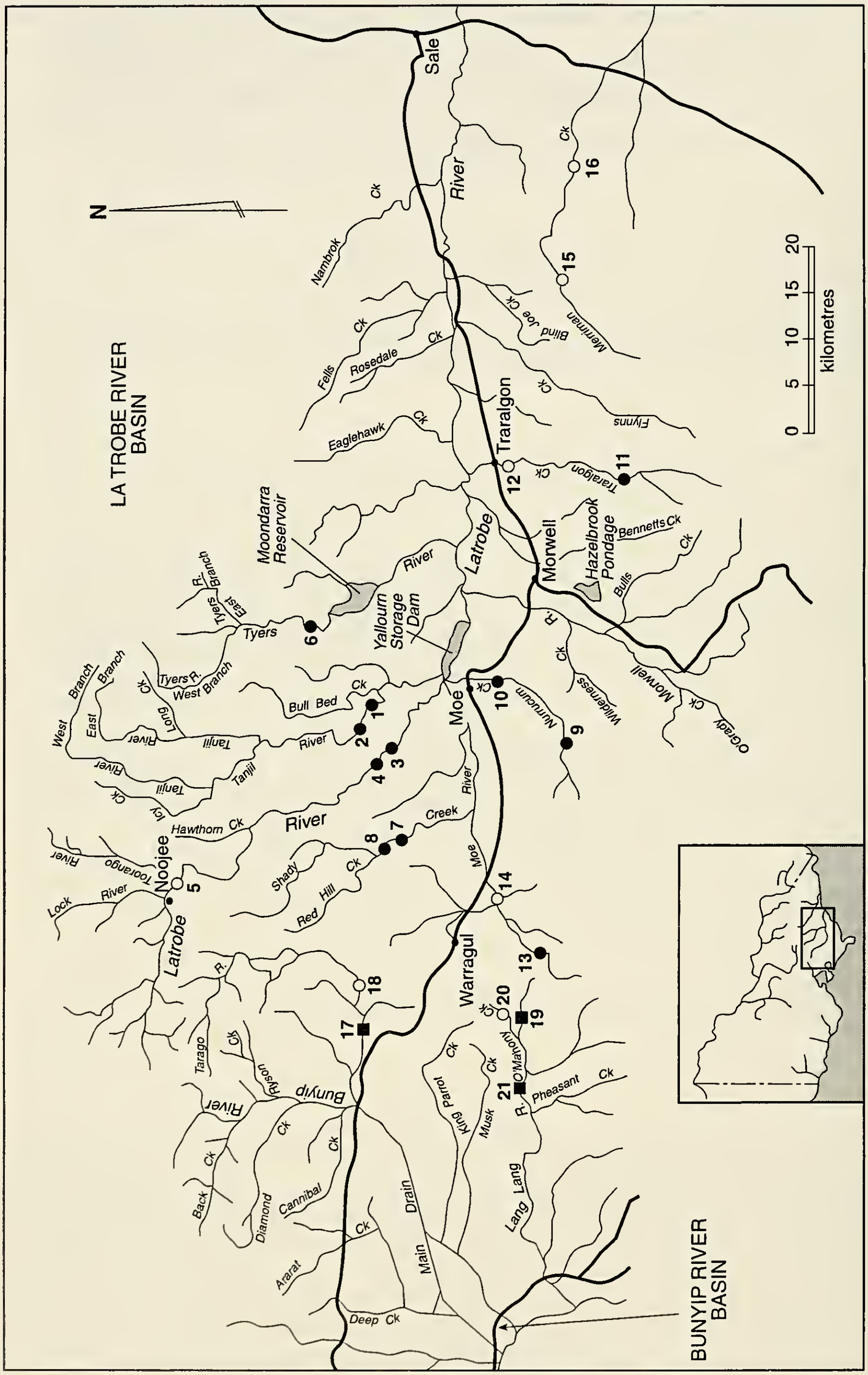

Figure 1. Sites surveyed for *Euastacus kershawi*, in the Bunyip and Latrobe River basins.
Key to symbols: ● = sites surveyed regularly 1987–1996; ❍ = sites surveyed 1987 only; ■ = sites surveyed intermittently since 1987. The Latrobe system was closed to the taking of crayfish 1982–1990.

Euastacus kershawi is one of the larger freshwater crayfish. It is considered somewhat of a delicacy amongst anglers and is actively fished for in spring and early summer. Concerns expressed by some groups over the exploitation of the species resulted in a ban on the taking of all species of freshwater crayfish in the Latrobe River system (along with several other Victorian river systems) in 1982. No prior surveys or monitoring was undertaken to justify the closure (Barker 1990; Morey 1987).

Following a review of the management of freshwater crayfish throughout Victoria, (Anon 1992; Barker 1990; Morey 1987), new regulations were introduced on 1 January 1991 removing the ban on the taking of crayfish in waters that were previously closed. At the same time, a general size limit of 90 mm Occipital Carapace Length (OCL) was imposed, except for the Glenelg River system (100 mm OCL), with a bag limit of ten per person per day (5 for the Glenelg River system). Gear restrictions were also added to the existing Recreational Fishing Regulations for Spiny Freshwater Crayfish (CNR 1992).

Objectives of this paper are: to analyse recapture data from long-term surveys to determine annual growth rates in terms of occipital carapace length (OCL) increments and annual weight increments; to document field observations on local movement, defence behaviour, reproduction and burrowing; to compare catch rates during and after a closure and gauge effects of restrictions on the *E. kershawi* fishery.

METHODS

Of the original 21 sites surveyed (Morey 1987), 11 sites in the Latrobe River catchment were monitored annually from 1987 to 1996, and a further two sites within the Bunyip River catchment were surveyed intermittently (Fig. 1). Sampling was conducted for four years (1987–1990) during the closure in the Latrobe River system. The other eight original sites were not monitored further because either no crayfish were collected in the 1987 survey or the sites could not be precisely relocated.

Originally, sites were selected on their accessibility (close to roads and popular with anglers), or their inaccessiblity (access only through private property) as controls. Most sites were located in cleared pasture, below the 200 m contour. Riparian vegetation consisted primarily of introduced pasture species, with an over-storey of willows, (*Salix* spp) or remnant *Eucalyptus* spp, with the exception of site 6 (Tyers River) and site 11 (Traralgon Creek), which both flowed through relatively natural vegetation.

At each site, baited drop nets (hoop nets) were deployed during daylight hours (0930–1730 hrs) when *E. kershawi* is reported to be most active. Nets were placed at 10-20 m intervals over a distance of approximately 200 m, preferably in the calmer water associated with holes in the river bed, but to retain the 10–20 m interval some nets were placed in faster flowing waters. The nets were lifted every 30 minutes over a period of between 2.5–4 hours (5–8 lifts). Any crayfish collected was sexed, weighed and measured (OCL), and individually tagged by clipping the telson and uropods as per Hume (1986). It was possible to detect tag marks for up to four years after initial tagging. Although some tag marks had healed over, scarring was evident at tagging sites on the tailfan. Specimens were returned to the water at site of capture and the nets replaced.

Regression analysis was used to analyse annual incremental growth with respect to OCL and weight, for both males and females. Analysis of variance using generalised linear models in Genstat was used to compare mean catch rates between open and closed seasons.

RESULTS

1063 crayfish have been caught, measured and marked at the 13 monitoring sites since 1987, but at most sites there were also escapes, individuals that fell through the

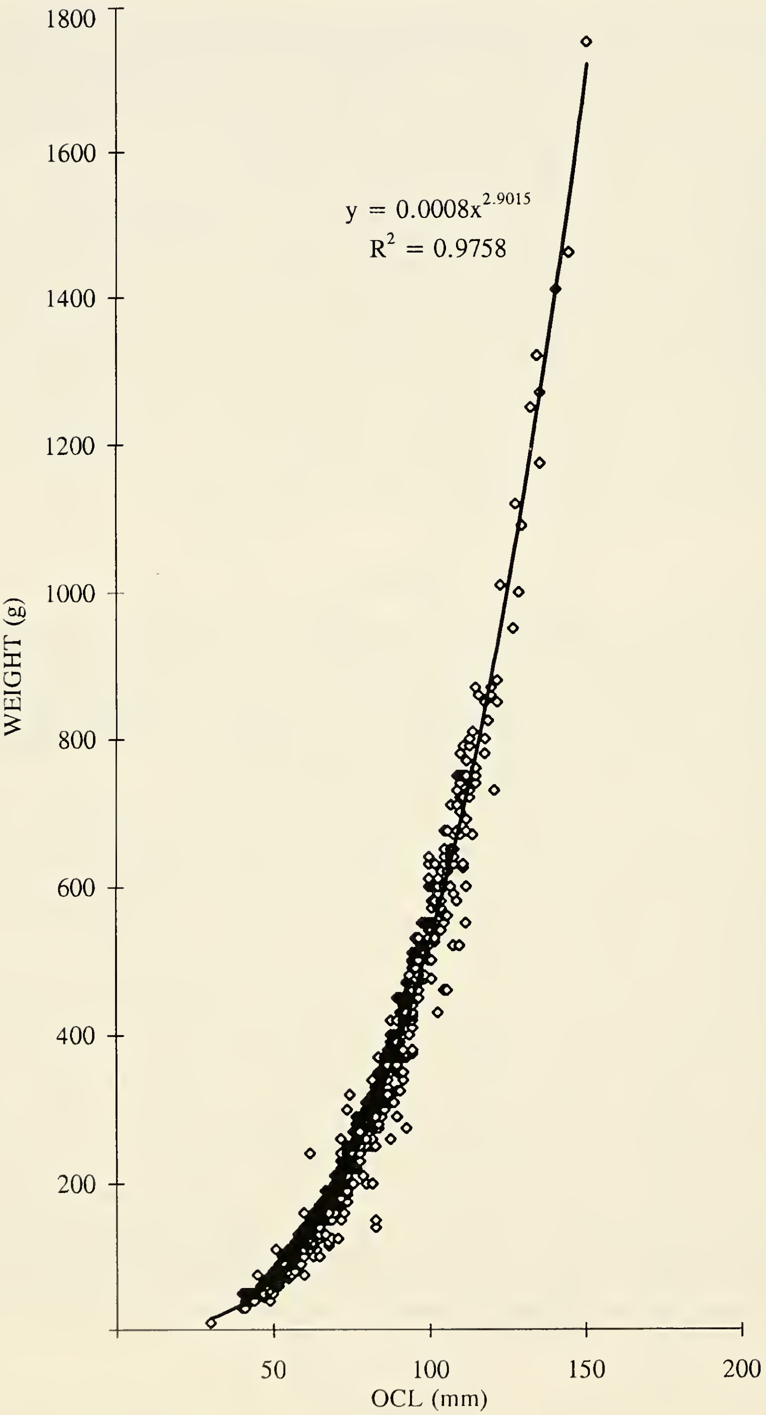

Figure 2. Relationship of occipital carapace length (OCL) to weight for both sexes of *E. kershawi*, in the Bunyip and Latrobe River systems. n = 1,093 (includes recaptured specimens).

mesh or were below or not completely in the net when lifted. The overall sex ratio at all sites was almost 1:1 (518 males, 564 females, 4 unknown or abnormal). The OCL-weight relationship indicated a non linear relationship with all crayfish gaining weight exponentially with length (Fig. 2).

Annual growth rates were calculated for recaptured specimens (change in OCL over time). Although three females showed no increase at all over a twelve month period, the overall mean annual growth increment was 6.7 mm/year. Individual increases varied from a minimum of 2 mm over a three year period to a maximum of 19 mm in twelve months, (three individuals — Table 3). Regression analysis for OCL increments for both sexes indicated there was a significant decrease in annual OCL increment ($P<0.01$), for female *E. kershawi*. The larger the individual, the less it grows in OCL each year (Fig. 3a). For males, there was no significant decrease in annual OCL increments ($P = 0.81$), suggesting a relatively uniform growth rate (Fig. 3b) The two largest recaptures were males (initial OCL 130 mm, 112 mm). Their OCLs increased by 15 mm over a 2 year period and 24 mm over a 3 year period respectively (average annual increments of 7.5 mm and 8 mm respectively). There were several "outliers" in Figure 3, these were rechecked and confirmed before inclusion. In one instance, two individuals from the same survey site (Bear Creek), had an annual increment of 19 mm, and one cray with a similar annual increment (19 mm) was recaptured from the Tanjil River.

Linear regressions of annual weight increases to mean weights indicated that there was no significant annual increase for females ($P = 0.38$), whereas there was a significant ($P<0.0001$) increase in annual increments as the males increased in mean weight, particularly at sizes exceeding 100 mm OCL and 600 g (Figs 4a,b). The placement of a log curve through the male data points appears to better represent this relationship (Fig. 4b).

Tagged crayfish were often recaptured in the original vicinity of capture, some up to four years after initial tagging. Others have been re-caught at varying distances (10 m to 160 m) away from the original capture site. Although several crayfish were caught in the same location (i.e. the same net) in successive lifts, very few lifts resulted in two or more crayfish in the same net. This behaviour tends to indicate a territorial defence behaviour where crayfish will defend their territory and/or food from others. Crayfish kept in close proximity to each other will fight, often inflicting severe damage, such as a crushed or punctured carapace or the loss of limbs. Many of the crayfish caught exhibited signs of injury such as lost or regenerating forelegs, tips of claws etc. (for example, 27 of 106 crayfish (25%) exhibited visible damage in the 1990 survey).

In this study only 30 (5.5%) of the 546 females captured were "in berry" or carrying juveniles, although almost 40% of females caught were considered sexually mature. Female *E. kershawi* had relatively broader abdomens than males and although abdominal widths were not measured, it was easy to identify mature females this way. Estimates of ova or young carried varied from 200 to 1000+ per female, the higher figure being the norm. With the exception of five females from Traralgon Creek (OCLs 65 mm, 67 mm, 69 mm, 73 mm and 80 mm), all berried *E. kershawi* had an OCL of 87mm or more.

E. kershawi were often observed on the banks adjacent to rivers and creeks, and, according to some landholders and recreational fishermen, crays have been found sometimes well into adjacent paddocks many metres from the waters edge. *E. kershawi* were observed excavating burrows in the banks of the Tanjil River in mid December and mid February, but it is not known whether they construct type 1b (connected to the permanent water) or type 2 burrows (connected to the water table) (Horwitz and Richardson 1986) or what sex they were. Freshly excavated burrows adjacent to waters have also been observed in October and November.

A total of 1086 crayfish were collected between 1987 and 1996 in a total of 6,414.5 net hours, an overall catch rate of 0.17 crayfish per net-hour for all sites sampled. Numbers caught at each site varied, but were generally fairly low (Table 1) with a

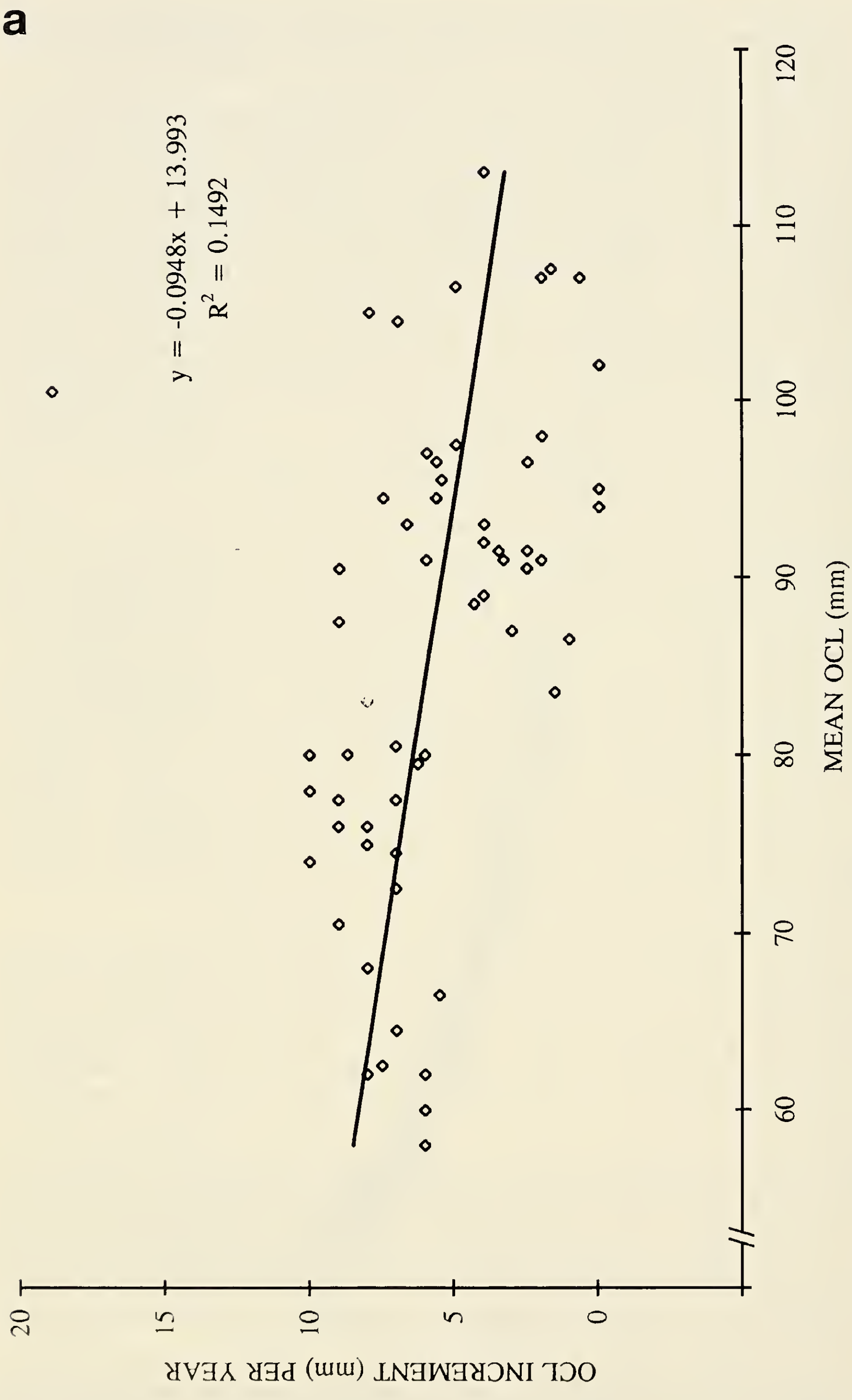

Figure 3. Relationship of occipital carapace length increment to mean OCL for *E. kershawi* from the Bunyip and Latrobe systems(1987–1996): (a) recaptured females; (b) recaptured males.

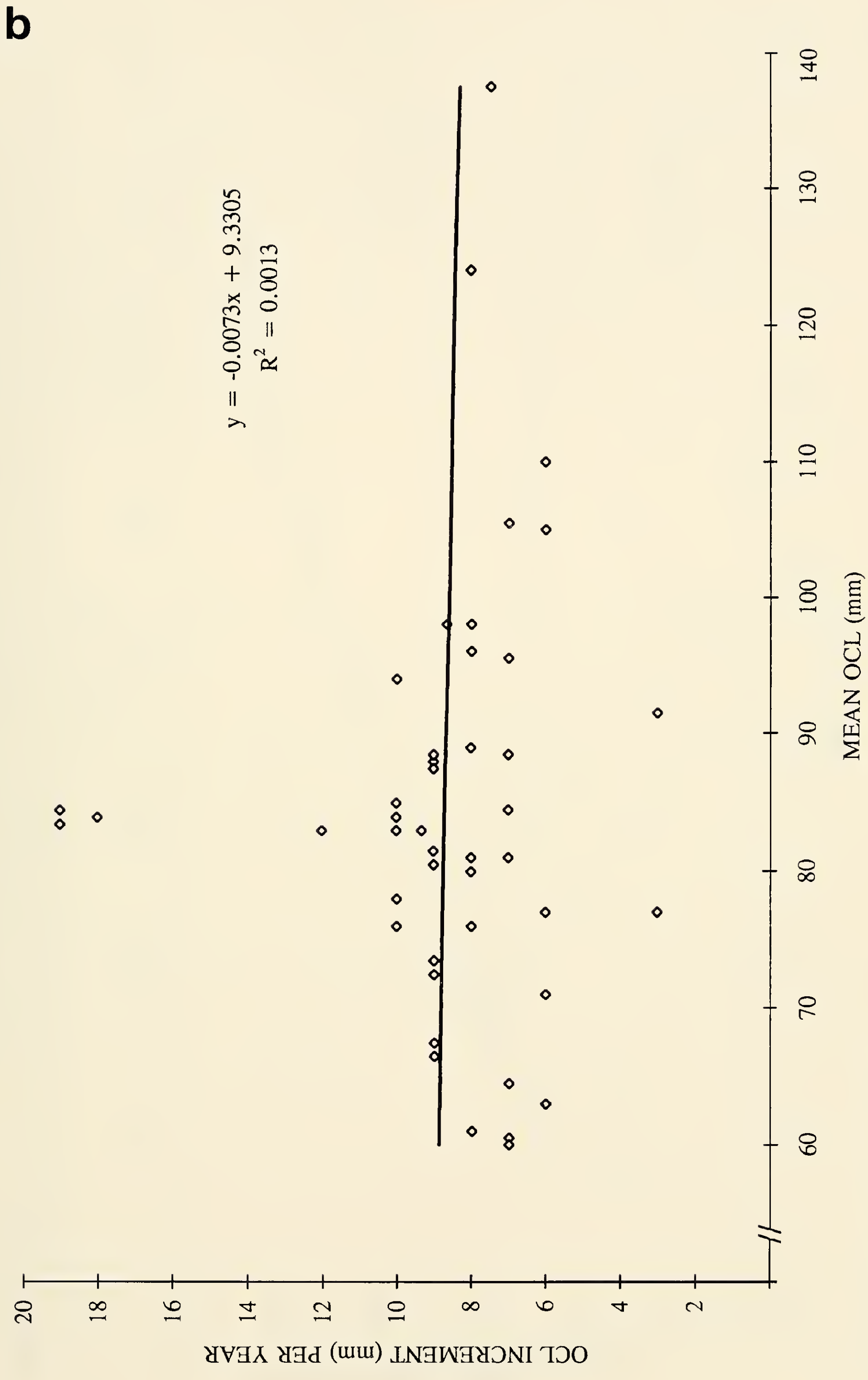

Figure 3 continued. (b) recaptured males.

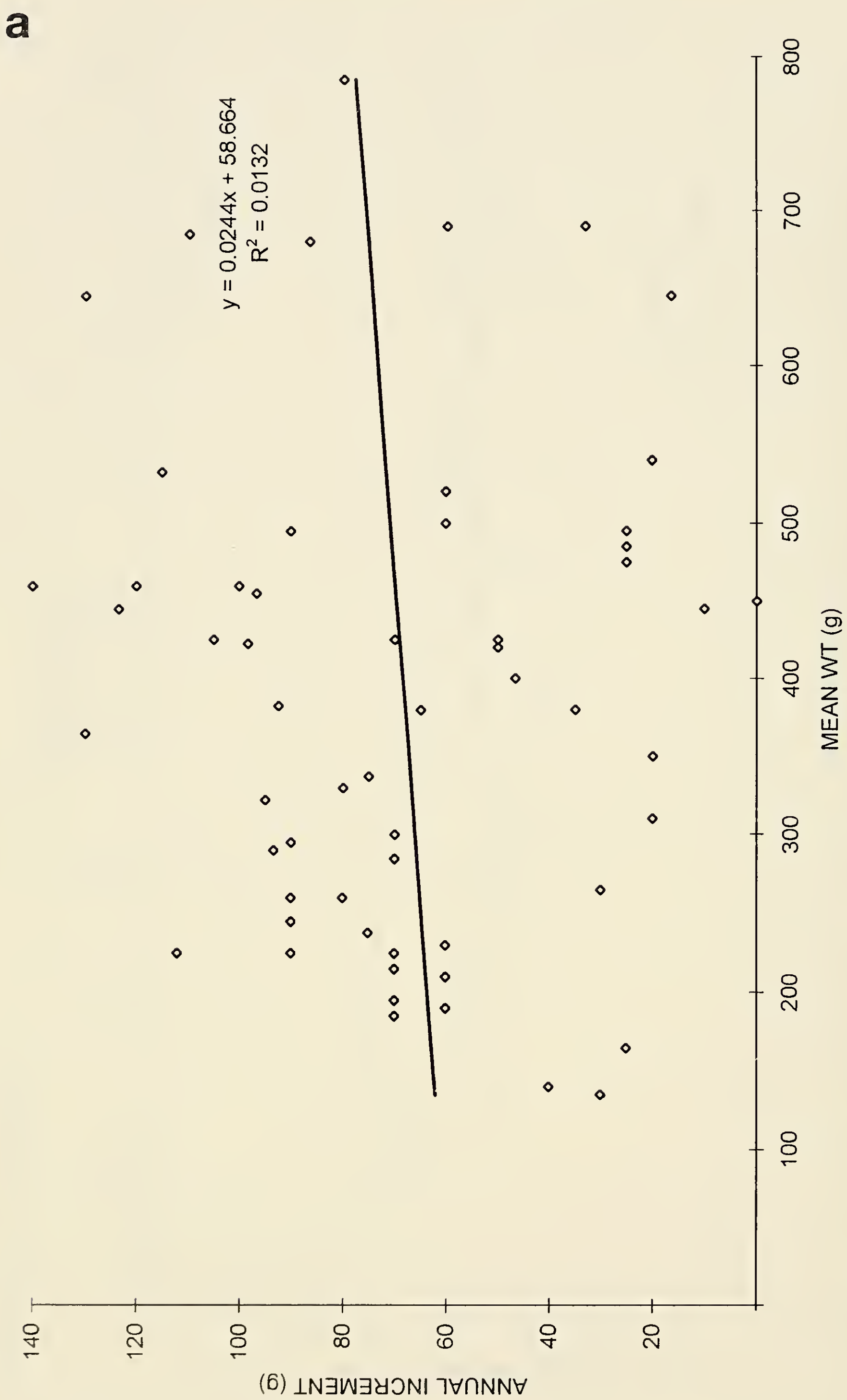

Figure 4. Relationship of annual weight increment to mean weight for *E. kershawi* from the Bunyip and Latrobe systems (1987–1996). (a) recaptured females; (b) recaptured males.

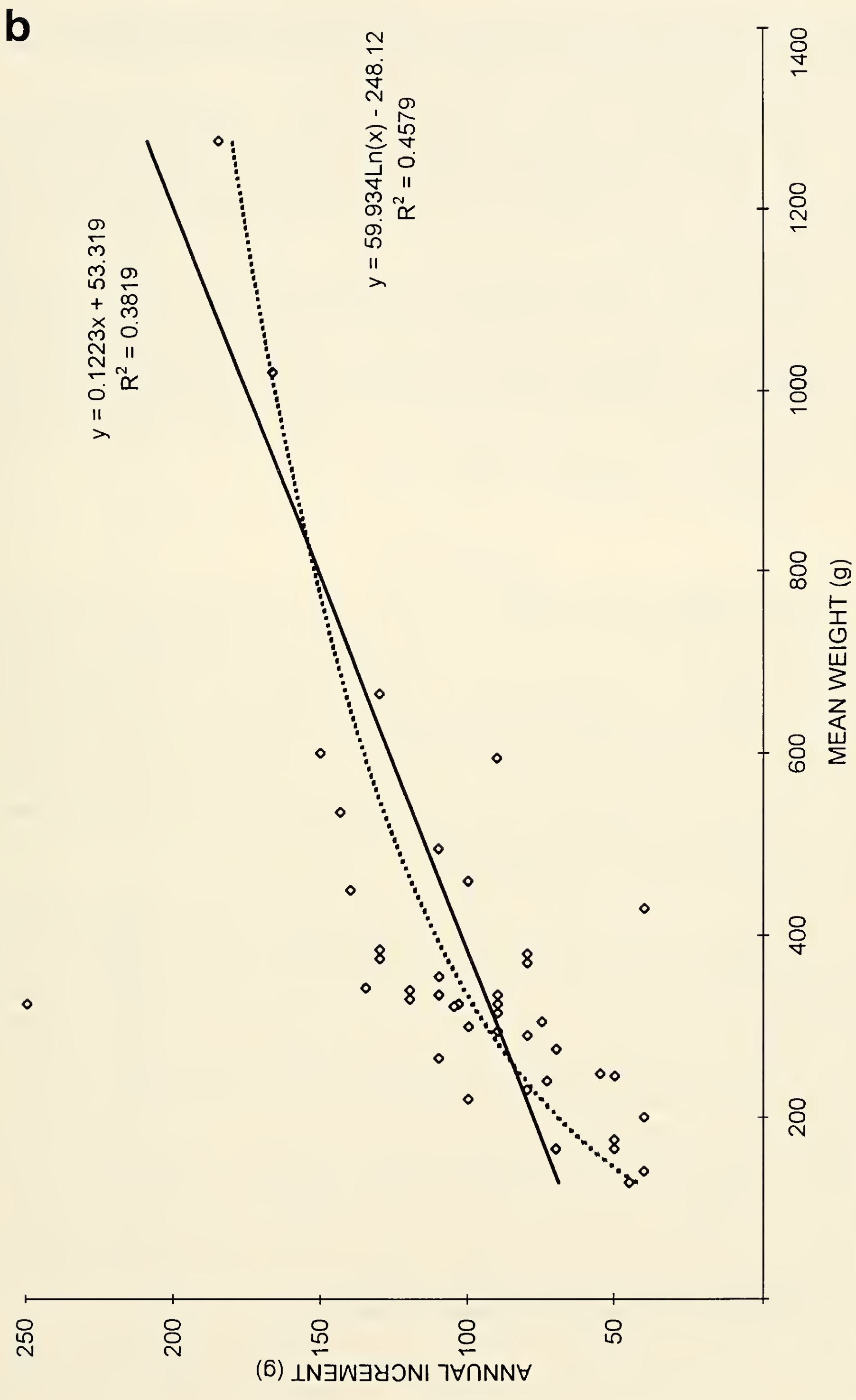

Figure 4 continued. (b) recaptured males.

maximum of 23 individuals caught during any one day during a survey (Site 8 in 1996). Catch rates were also generally low (Table 1) with a maximum of 0.50 crayfish per net-hour during any one survey (Site 6 in 1996).

Average catch rates between 1987-1990 (during the closed season) and 1991–1996 (after the closed season) increased at six of the 11 regularly surveyed sites (Sites 1, 2, 6, 8, 10 and 13), declined at 3 sites (Sites 3, 7, and 11) and remained constant at two sites (Sites 4 and 9). The mean catch rate at the two irregularly surveyed sites also remained constant. Analysis of variance using generalised linear models on the mean catch rates showed there was no significant difference between open and closed seasons ($P = 0.147$).

Similarly, the size/catch rate ratio also did not alter significantly (Table 2). Of the crayfish collected, 102 or 9.6% were recaptures, having been tagged on previous surveys (Table 3). Only two crayfish were recaptured again on the same day they were tagged.

Catch rates were related to the time that nets were left set, declining markedly the longer the nets were left immersed. When baited nets were left for a minimum of 2.5 hrs soak time, i.e. five lifts, 70% of the total catch was caught within the first three lifts (Table 4). Nets left longer than 2.5 hrs (up to a maximum of 4 hrs) still caught crays, but catches were lower (5–10 individuals on lift 7 or 8).

DISCUSSION

E. kershawi individuals grow very slowly. If *E. kershawi* grow at a uniform 6.7 mm/year (the average annual growth increment), a crayfish of minimum legal size of 90 mm OCL is about 13 years old. This is in close correlation, but a slightly slower growth rate, from estimates of size and age for *E. bispinosus*, as proposed by Honan and Mitchell (1995b) who estimated *E. bispinosus* to have lifespans exceeding 25 years. Even at a uniform rate of the highest growth rate recorded of 19 mm per year, a Gippsland Spiny Crayfish of minimum legal length is about 5 years old. The largest cray collected during this study had an OCL of 151 mm (from the Latrobe River in 1990), however a male specimen collected by a recreational angler in December 1996, also from the Latrobe River, at Noojee, had a confirmed OCL of 165 mm, 5.5 mm larger than the maximum OCL reported by Morgan (1986).

OCL increments were not uniform and varied between individuals and also years. For example, one individual grew 10 mm one year and 3 mm the following year. However, average growth rates at sites where a reasonable sample of recaptures were found (>5) was fairly constant (6.7–10.6 mm/year). Two of the three individuals that recorded the maximum increment of 19 mm were from the same site. There is no obvious explanation for these high values, but it is possible that these individuals had completed a double moult (i.e. they had moulted twice within the twelve month period). Honan and Mitchell (1995b) estimated that *E. bispinosus* individuals less that 45 mm OCL moulted twice annually and once per year for individuals over 55 mm OCL, although some large specimens (>110 mm OCL) did not moult at all or had a small increment. Similarly, Turvey and Merrick (1997d), estimated *E. spinifer* moults three times annually for individuals <35 mm OCL, twice per annum for individuals up to 55 mm OCL and annually for specimens over 55 mm OCL. With the exception of one individual (with initial OCL of 53 mm), all recaptured *E. kershawi* specimens had an initial OCL of 55 mm or greater, and are estimated to have moulted only once per year, except for those individuals that had either exhibited no annual increment, or had increased at approximately three times the annual average increment.

Male *E. kershawi* with OCLs in excess of 100 mm continued to grow at the annual average increment, whereas females showed a distinct decline in annual OCL increment, particular over 80 mm OCL. This is in contrast to Turvey and Merrick (1997e), who

TABLE 1

Numbers of *Euastacus kershawi* caught in each year at each site with catch rate (crayfish per net-hour) in parentheses. There was a closed season on the taking of crayfish until 1991 in all waters except Sites 17 and 19 (Tarago River and Minnieburn Creek). Inclement weather prevented some surveys in 1992.

Site	1987	1988	1989	1990	mean	1991	1992	1993	1994	1995	1996	mean
			closed						**open**			
1	11(0.12)	5(0.06)	8(0.20)	8(0.13)	8(0.13)	10(0.25)	9(0.30)	10(0.22)	12(0.27)	15(0.39)	19(0.38)	12.5(0.30)
2	13(0.26)	12(0.41)	5(0.18)	17(0.28)	11.8(0.28)	10(0.25)	9(0.30)	11(0.31)	18(0.44)	14(0.37)	9(0.19)	11.8(0.31)
3	3(0.08)	6(0.16)	8(0.28)	4(0.08)	5.3(0.15)	3(0.08)	—	4(0.09)	5(0.10)	7(0.15)	4(0.09)	4.6(0.10)
4	3(0.05)	1(0.03)	7(0.25)	13*(0.09)	6(0.11)	13*(0.05)	—	8(0.18)	7(0.14)	3(0.06)	5(0.11)	7.2(0.11)
6	5(0.15)	1(0.02)	2(0.06)	7(0.19)	3.8(0.11)	9(0.23)	—	17(0.45)	8(0.24)	12(0.33)	19(0.50)	13(0.35)
7	6(0.18)	16(0.23)	18(0.40)	41*(0.13)	20.3(0.24)	21*(0.07)	13(0.16)	12(0.09)	17(0.34)	22(0.44)	7(0.15)	15.3(0.21)
8	9(0.14)	20(0.32)	9(0.34)	16(0.32)	13.5(0.28)	21*(0.26)	13(0.28)	11(0.13)	22(0.46)	18(0.36)	23(0.48)	21.5(0.33)
9	12(0.33)	6(0.16)	9(0.28)	28*(0.12)	13.8(0.22)	14*(0.09)	—	8(0.17)	14(0.31)	15(0.32)	10(0.20)	12.2(0.22)
10	1(0.04)	6(0.20)	6(0.21)	6(0.12)	4.8(0.14)	5(0.13)	—	7(0.15)	20(0.44)	9(0.18)	3(0.06)	8.8(0.19)
11	4(0.15)	6(0.27)	4(0.11)	14(0.23)	7(0.19)	4(0.11)	—	8(0.15)	3(0.06)	—	6(0.13)	5.3(0.11)
13	9(0.21)	15(0.38)	16(0.36)	9(0.27)	12.3(0.30)	10(0.17)	14(0.46)	3(0.07)	4(0.11)	8(0.17)	17(0.36)	9.3(0.22)
17	3(0.14)	—	—	13*(0.08)	4(0.11)	2*(0.11)	—	7(0.19)	7(0.14)	4(0.08)	1*(0.02)	4.2(0.11)
19	4(0.07)	—	—	8(0.13)	3(0.10)	—	—	4(0.11)	6(0.13)	5(0.11)	2(0.04)	4.3(0.10)

* Numbers caught over more than one days survey.

TABLE 2

Number of *Euastacus kershawi* 90mm or more Occipital Carapace Length and percentage (in parentheses) of total catch. Not all sites were surveyed in 1992.

SITE	1987	1988	1989	1990	mean	1991	1992	1993	1994	1995	1996	mean
			closed						**open**			
1	8(73%)	1(20%)	5(63)%	5(63%)	4.8(5%)	5(50%)	3(33%)	4(40%)	8(67%)	3(20%)	8(42%)	5.2(4%)
2	3(23%)	7(58%)	2(40%)	7(59%)	4.8(4%)	6(60%)	0(0%)	3(27%)	8(44%)	4(29%)	4(44%)	4.2(3%)
3	3(10%)	2(33%)	1(13%)	3(75%)	2.3(4%)	2(66%)	—	3(75%)	0(0%)	3(43%)	1(25%)	1.8(3%)
4	1(33%)	0(0%)	1(14%)	6(46%)	2(33%)	5(38%)	—	5(63%)	1(14%)	1(33%)	3(60%)	3(42%)
6	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	—	0(0%)	1(13%)	0(0%)	1(5%)	0.4(3%)
7	3(50%)	5(31%)	6(33%)	5(12%)	4.8(2%)	1(5%)	3(23%)	4(33%)	1(6%)	1(5%)	0(0%)	1.7(1%)
8	4(44%)	10(50%)	0(0%)	3(19%)	4.3(3%)	4(19%)	1(8%)	3(27%)	7(32%)	0(0%)	2(9%)	2.8(1%)
9	6(50%)	1(17%)	3(33%)	12(43%)	5.5(4%)	0(0%)	—	0(0%)	0(0%)	4(27%)	6(60%)	2(16%)
10	0(0%)	3(50%)	2(33%)	2(33%)	1.7(3%)	1(20%)	—	2(29%)	3(15%)	1(11%)	0(0%)	1.4(16%)
11	0(0%)	1(17%)	1(25%)	1(7%)	0.7(1%)	0(0%)	—	1(13%)	2(67%)	—	0(0%)	0.7(14%)
13	4(44%)	3(20%)	6(38%)	7(37%)	5(41%)	2(20%)	2(14%)	0(0%)	0(0%)	2(25%)	1(6%)	1.2(12%)
17	0(0%)	—	—	0(0%)	0(0%)	0(0%)	—	2(29%)	0(0%)	1(25%)	0(0%)	0.6(14%)
19	4(100%)	—	—	6(75%)	5(83%)	—	—	3(75%)	5(83%)	5(100%)	2(100%)	3.7(88%)

reported no difference in growth related to sex for *E. spinifer*. France (1985) noted annual growth rates declined with age for a North American freshwater crayfish, *Orconectes virilis*. Similarly, Turvey and Merrick (1997e) and Honan and Mitchell (1995b) reported declining annual increments for *E. spinifer* over 55 mm OCL, and *E. bispinosus* over 110 mm, respectively. Why male *E. kershawi* appear to continue growing at a relatively constant rate is unexplained. The largest female *E. kershawi* captured had an OCL of 122 mm, whilst there were 10 males with an OCL of 122 mm or more.

The low recovery rates in this study may indicate either heavy fishing pressure, mobile populations or high population numbers within these waters. The catch/effort results and anecdotal evidence tend to suggest fairly low resident populations due to fishing pressure. Honan and Mitchell in their study on catch characteristics of *E. bispinosus* (1995c) found most tagged individuals moved less than 75 m from the capture site. Similarly, most recaptured *E. kershawi* (85%) were recovered within 60 m of the original capture site. Honan and Mitchell (1995a) also noted some *E. bispinosus* exhibited missing appendages or wounds, and in their 1995b report mentioned one in four large *E. bispinosus* with missing or regenerate chelae. Similar observations have been reported by Bicskos (1989), for *E. armatus*. Damage to individuals is consistent with territorial defence behaviour.

All five berried females from Traralgon Creek had an OCL of 80 mm or less, whilst berried *E. kershawi* from all other sites had an OCL of 87 mm or more. 82.6% (19 females) had an OCL of 90 mm or more, but it is not known why the Traralgon Creek population matures at a lesser OCL than all other sites.

Six *E. yarraensis*, a sympatric species in the Tarago River, were collected during the survey period, including one female in berry with an OCL of 52 mm. *E. yarraensis* were included in the catch rate data, however no recaptures of previously tagged specimens precluded any growth estimates.

TABLE 3

Recapture and growth rates of *Euastacus kershawi*, for the 11 regularly and 2 irregularly surveyed sites. Two "outliers" (due to recording errors), not included.

Location	(Site)	Total Caught	Recaptures	Percentage of recaptures	OCL increase range (mm)	Average annual OCL increase (mm)
Tanjil River	(1)	100	6	6.0	1.7–10	5.5
	(2)	101	15	14.9	2–19	7.4
Latrobe River	(3)	44	0	0	—	—
	(4)	54	5	9.3	5–8	7.1
Tyers River	(6)	76	4	5.3	6–9.3	7.6
Shady Creek	(7)	166	22	13.3	0–18	8.0
	(8)	130	23	17.7	0–10	6.9
Narracan Creek	(9)	108	10	9.3	5.5–15	8.7
	(10)	60	3	5	6–10	8.3
Traralgon Creek	(11)	46	2	4.3	1–3	1.8
Bear Creek	(13)	109	7	6.4	0–19	7.9
Tarago River	(17)	44	1	2.3	0	0
Minnieburn Creek	(19)	25	4	16	0.7–8	4.4
TOTAL		1063	102	9.6	0–19	6.7

TABLE 4

Catch of *Euastacus kershawi* compared to lift, when nets were left for a minimum of 2.5 hours, (nets were lifted every 30 minutes, i.e. five lifts), for all surveys 1990 and 1991.

Lift No.	1	2	3	4	5
No. of crayfish	72	52	35	32	33
Cumulative total	72	124	159	191	224
Percentage of total	32%	55%	71%	85%	100%

In contrast to this study, where low numbers of berried *E. kershawi* were recovered, Honan and Mitchell (1995a) reported up to 95% of mature female *E. bispinosus* carried eggs in the breeding season and remained active and catchable. Like some other freshwater cray species, it is possible that berried *E. kershawi* are more secretive, trap shy, or confined to burrows, making them more difficult to catch (Abrahamson 1971; Huner 1988; Lowery 1988); have low spawning rates (France 1985; Huner and Lindqvist 1986) or that the breeding period for *E. kershawi* is outside the survey period (late August–early November), although Clark (1937) reported the breeding season for the Gippsland Spiny Crayfish as early spring. Hamr and Richardson (1994) reported *Parastacoides tasmanicus* and other species as having a biennial breeding cycle, however Honan and Mitchell (1995a) and Turvey and Merrick(1997a) reported *E. bispinosus* and *E. spinifer* as having annual breeding cycles.

What stimulates *E. kershawi* to leave the water and travel overland or why and when they excavate burrows is unknown and requires further research.

The apparent lack of change in the catch rate and size components of the populations questions the effectiveness of the closure on the taking of crayfish in the eighties. As this project progressed, it became apparent (through evidence of discarded bait lines or advice from landholders) that all the “inaccessible” sites were frequented by anglers seeking freshwater crayfish. Evidence of poaching at several sites (and at other locations on the Latrobe River and its tributaries) during the fishing ban, and comments from adjacent landholders also supports the apparent lack of effectiveness of the closure. Similarly, illegal fishing was observed in a reserve established for the the large Tasmanian freshwater crayfish, *Astacopsis gouldi*; the closure of the area was reported to be ineffective in limiting harvesting of that species (Horwitz and Hamr 1988). Non compliance with the closure of certain waters to the taking of freshwater crayfish in the eighties would also explain the similarity in the catch rates of the “open” and “closed” waters in the initial 1987 survey.

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